Wing Damages of Butterflies and Birds' Attacks

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Abstract In order to determine whether the distinctive damages on butterfly wings, so-called "beak marks", were inflicted only by birds' attacks, an experiment was carried out in the laboratory using butterflies of the genus *Pieris* as subjects. Control butterflies were put in a cage with branches as obstacles and were allowed to fly freely, while experimental butterflies were subjected to predatory attacks of caged birds (Varied Tits, Great Tits and Bush Warblers). The wing damages of both samples were then analyzed. It was concluded that large damages, especially large symmetrical damages, resulted only from birds' attacks, although not all symmetrical damages were caused by birds' attacks.

Introduction

Wings of adult butterflies and moths are very fragile and break easily by rough handling, but in nature they sometimes leave traces of attacks by some insectivorous predators such as birds and lizards. Wild-caught samples of butterflies and moths often have distinctive wing damages such as symmetrical notches or missing parts torn off linearly. Such damages, so-called "beak marks", have been considered indirect, but strong, evidence of actual attack by birds (BENSON, 1972; CARPENTER, 1935, 1941; MATSUI, 1983; ROBBINS, 1980, 1981; SARGENT, 1973; SMITH, 1979; STERNBURG *et al.*, 1977).

Although it seems undoubted that such damages result only from the predators' attacks, there is no experimental study that has shown this fact except SARGENT's (1973) work using *Catocala* moths and blue jays. In the present study I carried out an experiment to determine whether distinctive wing damages of butterfly stemmed not from sharp obstacles occurring in nature, but from attacks by birds.

Materials and Methods

Butterflies

The butterflies used for this study were adults of three species belonging to the genus *Pieris* (Lepidoptera: Pieridae), *P. rapae crucivora*, *P. melete* and *P. napi japonica*. Butterflies with no or little damage on their wings were collected in nature, or were obtained from pupae reared in the laboratory. Of 173 butterflies used in this study, only 7 individuals were *P. melete* and 2 were *P. napi*. Although these three species were known to be slightly different in behavior (OHSAKI, 1980), this posed no problem for the experimentation.

蝶と蛾 *Tyô to Ga*, **35** (4): 202–207, 1985

Control Samples

One hundred and sixteen butterflies were used as the control samples. Five to 10 individuals per test were put in a wire-net cage (25 × 30 × 37 cm) and provided with a dilute solution of sucrose as food and dead branches as obstacles. Butterflies were allowed to fly freely in the cage until they died in several days with a range of 1 to 8 days. The dead butterflies were collected every day for analysis of wing damages.

Experimental Samples

Fifty-seven butterflies were subjected to the attacks of three species of insectivorous birds. Three Varied Tits (*Parus varius*), 4 Great Tits (*Parus major*) and 3 Bush Warblers (*Cettia diphone*) were used and each bird was kept in an individual cage. This cage was slightly larger (40 × 40 × 45 cm) than control one.

In each experimental trial one butterfly, weakened by pressing its thorax so that it could not move swiftly, was introduced into the bird cage. When the bird attacked the butterfly, the bird was given 20 seconds as "handling time". Then the attacked butterfly was taken out for analysis of wing damage. If the butterfly was not attacked by the bird, it was taken out 3 min after introduction to the cage. Then the wing damages of these samples were analyzed.

Recording of Damages

The damages to butterfly wings in both control and bird-attacked samples were analyzed and the data recorded as to: (1) positions in wings in which the damage was present, and (2) type of the damage.

The outer margins of fore- and hindwing were divided into five regions (Fig. 1) for recording the damage positions. All damages were categorized into four types

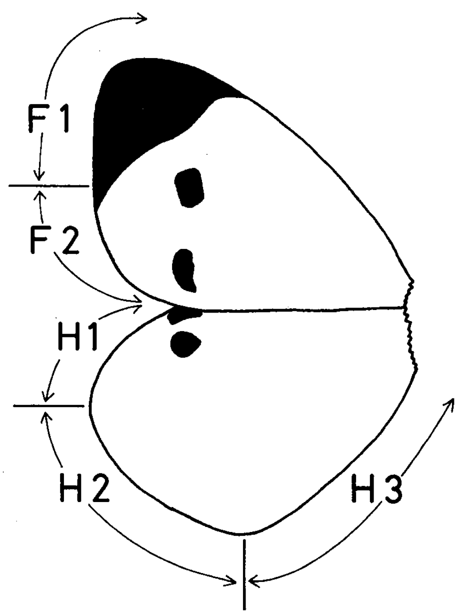

Fig. 1. Five regions of the wing margins used in recording the position of damage. The left wings of an adult *Pieris rapae* are shown.

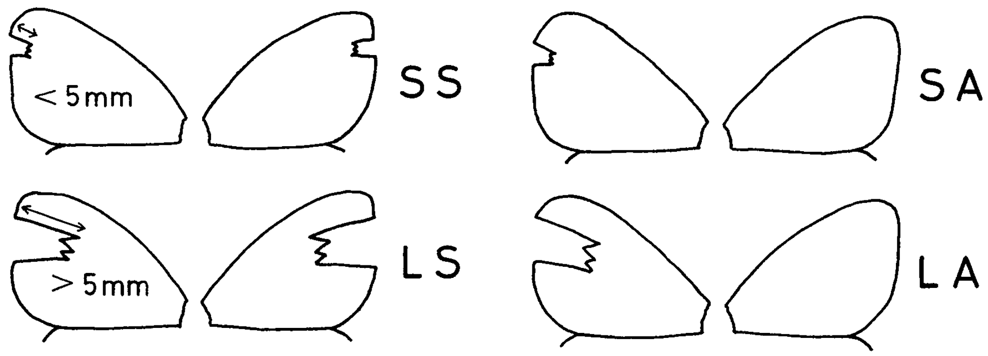

Fig. 2. Types of wing damage. SS: Small symmetrical damage. LS: Large symmetrical damage. SA: Small asymmetrical damage. LA: Large asymmetrical damage.

(Fig. 2). Symmetrical damage ("SS" or "LS" in Fig. 2) on right and left wings was counted as one occurrence.

Results and Discussion

Table 1 shows the number of individuals with and without damages in both control and bird-attacked samples. Since there are some reports that tits differ in feeding habits from other birds (e.g., ALCOCK, 1971), the samples attacked by tits (Varied Tits and Great Tits) and Bush Warblers are shown separately. Four butterflies given to Bush Warblers were not attacked, probably because those butterflies were presented in the early stage of the experiment. The remaining 53 butterflies were all attacked by tits and warblers.

Table 1. Number of butterflies with and without damages in the control and two experimental samples.

	With damage	Without damage	Total
Control[a]	68	48	116
Tit-attacked[b]	32	0	32
Warbler-attacked[c]	21	4	25

a: Free-flying in the cage. b: Given to Varied- and Great Tits. c: Given to Bush Warblers.

A total of 106 damages in the control samples, 78 in the tit-attacked samples and 53 in the warbler-attacked samples was counted. Distribution of number of damages by wing regions and by damage types are shown in Tables 2 and 3, respectively. In Table 2, significant differences in the distribution pattern were detected between control samples and both bird-attacked samples ($P<0.001$ in both comparisons, by χ^2-test). Most of the damages in the control samples were in the F1 region, the upper half of the forewings, while bird-inflicted damages were seen predominately in regions F1, F2 and H2. However, it is impossible to judge with certainty whether damage on butterfly wings has resulted from a natural obstacle or from an attack by a bird, only by considering the region of damage on the wing. It is more appropriate to analyze the type of damage.

Table 2. Distribution of the number of damages by region of wing margins (see Fig. 1 for code).

	Region of wing margins					Total	χ^2-test	
	F1	F2	H1	H2	H3		Comparison	χ^2
(1) Control	67	10	6	14	9	106	(1) vs. (2)	37.11[a]
(2) Tit-attacked	31	22	1	17	7	78	(1) vs. (3)	47.29[a]
(3) Warbler-attacked	18	18	2	14	1	53	(2) vs. (3)	0.61[b]

a: $P<0.001$. b: Not significant ($P>0.05$).

Table 3. Distribution of the number of damages of four types.

	SS	LS	SA	LA	Total
(1) Control	22	1	73	10	106
(2) Tit-attacked	6	16	25	31	78
(3) Warbler-attacked	4	18	12	19	53

SS: Small symmetrical damage. LS: Large symmetrical damage. SA: Small asymmetrical damage. LA: Large asymmetrical damage. (see Fig. 2).

Table 4. Comparisons of the types of damages.

(a) symmetrical vs. asymmetrical damages.

	Damages		χ^2-test	
	Symmetrical	Asymmetrical	Comparison	χ^2
(1) Control	23	83	(1) vs. (2)	1.04[c]
(2) Tit-attacked	22	56	(1) vs. (3)	6.83[a]
(3) Warbler-attacked	22	31	(2) vs. (3)	2.51[c]

(b) small vs. large damages

	Damages		χ^2-test	
	Small	Large	Comparison	χ^2
(1) Control	95	11	(1) vs. (2)	51.73[b]
(2) Tit-attacked	31	47	(1) vs. (3)	59.22[b]
(3) Warbler-attacked	16	37	(2) vs. (3)	1.24[c]

(c) large symmetrical vs. other types of damages

	Damages		χ^2-test	
	Large symmetrical	Others	Comparison	χ^2
(1) Control	1	105	(1) vs. (2)	20.56[b]
(2) Tit-attacked	16	62	(1) vs. (3)	36.78[b]
(3) Warbler-attacked	18	35	(2) vs. (3)	2.96[c]

a: $P<0.01$. b: $P<0.001$. c: Not significant ($P>0.05$).

The data of Table 3 were arranged in three ways according to the following criteria of comparison: (1) symmetrical vs. asymmetrical damages, (2) small vs. large damages and (3) large symmetrical vs. other types of damages. Table 4 summarizes the results of these three kinds of comparisons. In the comparison between symmetrical and asymmetrical damages (Table 4a), a significant difference was detected only between control and warbler-attacked samples ($P<0.01$, by χ^2-test), and no difference was detected between control and tit-attacked samples ($P>0.3$). However, striking differences were detected between control and both of bird-attacked samples in the comparison of damage size (small vs. large damages, Table 4b), and the same results were obtained from the comparison between large symmetrical damages and others (Table 4c). In all three comparisons there was no significant difference between the samples attacked by tits and warblers ($0.05<P<0.3$, by χ^2-test), suggesting that the difference in feeding habits observed between tits and warblers (JOHKI & HIDAKA, in prep.) did not have an important effect on the shape of damage by bird's beak.

From these results, the following conclusions are drawn. First, symmetrical damage is not exclusively inflicted by birds' attacks. There were 22 small symmetrical damages in the control samples (Table 3), which suggests that symmetrical damage, if it is small, is likely to stem from collisions with obstacles occurring in natural conditions. This result differs from that of ROBBINS (1980), who confined lycaenid butterflies in an out door net cage with sharp obstacles, but could find no symmetrical damages on the wings of those butterflies. However, he might have regarded only large symmetrical damages as "symmetrical".

Second, most large damages result from birds' attacks (Table 4b), and especially, large symmetrical damages. There was only one exception (Table 4c), and this exceptional damage, however, appeared somewhat asymmetrical. There was no clear, large symmetrical damage in the control samples.

Conclusions obtained from this study should be applicable to field studies on the ecology and behavior of butterflies. As described in the Introduction, there are several reports of wing damages in wild-caught butterflies, and the conclusions of my study provide experimental evidence that distinctive "beak marks" result from birds' attacks. However, caution is necessary, because the incidence of "beak marks" on butterfly wings does not always reflect the intensity of bird predation, as EDMUNDS (1974) has pointed out. More detailed field observations and careful mark-and-recapture studies as by BENSON (1972) and ROBBINS (1980, 1981) are needed.

Acknowledgements

The author thanks Prof. Dr. T. HIDAKA of Kyoto University and the members of his laboratory for their valuable suggestions. Thanks are also due to Dr. Y. SATO of Kyoto University, who kindly provided the butterflies obtained from pupae for my experiment, and to the anonymous referee for helpful comments on the manuscript. This work was supported in part by a Grant-in-Aid for Special Project Research on Biological Aspects of Optimal Strategy and Social Structure from the Japan Ministry of Education, Science and Culture.

References

ALCOCK, J., 1971. Interspecific differences in avian feeding behavior and the evolution of Batesian mimicry. *Behaviour*, **40**: 1–9.

BENSON, W. W., 1972. Natural selection for Müllerian mimicry in *Heliconius erato* in Costa Rica. *Science*, **176**: 936–939.

CARPENTER, G. D. H., 1935. Attacks of birds upon butterflies. *Nature*, **135**: 194–195.

——— 1941. The relative frequency of beak-marks on butterflies of different edibility to birds. *Proc. Zool. Soc. Lond.*, **111** (A): 223–231.

EDMUNDS, M., 1974. Significance of beak marks on butterfly wings. *Oikos*, **25**: 117–118.

MATSUI, H., 1983. *Vanessa cardui* attacked by a predator. *Kontyû to Shizen*, **18** (14): 36–37 (In Japanese.)

OHSAKI, N., 1980. Comparative population studies of three *Pieris* butterflies, *P. rapae*, *P. melete* and *P. napi*, living in the same area. II. Utilization of patchy habitats by adults through migratory and non-migratory movements. *Res. Popul. Ecol.*, **22**: 163–183.

ROBBINS, R. K., 1980. The lycaenid "false head" hypothesis: historical review and quantitative analysis. *J. Lepid. Soc.*, **34**: 194–208.

——— 1981. The "false head" hypothesis: predation and wing pattern variation of lycaenid butterflies. *Am. Nat.*, **118**: 770–775.

SARGENT, T. D., 1973. Studies on the *Catocala* (Noctuidae) of southern New England. IV. A preliminary analysis of beak-damaged specimens, with discussion of anomaly as a potential anti-predator function of hindwing diversity. *J. Lepid. Soc.*, **27**: 175–192.

SMITH, D. A. S., 1979. The significance of beak marks on the wings of an aposematic, distasteful and polymorphic butterfly. *Nature*, **281**: 215–216.

STERNBURG, J. G., G. P. WALDBAUER & M. R. JEFFORDS, 1977. Batesian mimicry: Selective advantage of color pattern. *Science*, **195**: 681–683.

摘　　要

チョウの翅の傷と鳥の攻撃（常喜　豊）

一般に鱗翅目成虫が鳥などの捕食者に攻撃されてのがれた場合，翅にV字形の模様や切れ込み (beak mark) や大きくえぐれた傷ができると考えられているが，このような傷が鳥の攻撃以外の原因で生じないかどうかを室内実験により調べた．

実験は *Pieris* 属の3種のチョウ（モンシロチョウ，スジグロチョウ，エゾスジグロチョウ）を用いた．野外で捕えた無傷の成虫，あるいは室内で蛹から羽化させたものを，枯枝などの障害物を設置したケージに入れて自由に飛び回らせたものを対照区，ヤマガラ・シジュウカラ・ウグイスの3種の鳥に与えて攻撃させたものを実験区として，両サンプルのチョウの翅についた傷を記録，比較した．

この結果，小さな対称傷は実験区・対照区どちらのサンプルにも見られたが，大きな傷，特に大きな対称傷は鳥の攻撃によってのみ特異的に生じることが明らかになった．